A STUDY OF THE EFFECTS OF KINESTHETIC LESSONS ON THE ACHIEVEMENT OF ALGEBRA II STUDENTS

By

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CHAPTER I

INTRODUCTION

Introduction

Each individual has a unique way of learning. As far back as Aristotle's time, teachers have recognized that students bring different talents and skills to the classroom (Reiff, 1992). However, in most modern classrooms, teachers deliver lessons in ways which ignore these talents and strengths. Over the past thirty years, researchers such as Barbe and Swassing (1979), Dunn and Dunn (1972), Gregoric (1979), Kolb (1976), McCarthy (1990), and Reinert (1976) have all studied, developed and tested theories involving the way people learn new knowledge (DeBelle, 1989; Reiff, 1992). The way that a learner concentrates on, processes and retains new and difficult information has been defined as learning style (DeBello, 1989; Dunn, 1993). Over the past decade, learning style has become one of the major elements in the "movement to make learning and instruction more responsive to the needs of the individual student" (Raviotta, 1988, pg 1). Specifically, research investigating the relationship between academic achievement and individual learning style has consistently supported the following contentions: (a) students learn differently from each other; (b) student performance in different subject areas is related to how individuals learn; and (c) when students are taught with methods that are consistent with their unique way of learning, their achievement is significantly increased (Dunn, Dunn, & Price, 1987).

Learning styles can be classified and identified in a number of different ways, often depending on which theorist's approach is being followed. What is not different is that learning styles directly affect how students learn. One of the ways in which learning styles is classified is in the area of cognitive perceptual preferences or learning modalities. These are the senses through which people take in and process knowledge. The four modalities most often recognized are visual (learning by seeing), auditory (learning by hearing), tactile (learning by touching), and kinesthetic (learning through body movement (Dunn and Dunn, 1993; Reiff, 1992).

Two decades of research show that students introduced to material through their perceptual preferences remember significantly more than when their perceptual strengths are ignored (Dunn, et al., 1995). Many teachers in today's classroom still teach primarily through lecture and independent work (Hall, 1993). This would meet the needs of those students with auditory and possibly visual strengths. Therefore, it is not surprising to find that many students who do not do well in school tend to report a tactile or kinesthetic strength as their primary learning modality (Dunn and Dunn, 1993; Reiff, 1992).

Statement of the Problem

In a typical high school Algebra II classroom, most lessons are delivered either auditorially or visually. The Third International Mathematics and Science Study found that most math lessons in the United States are delivered in the following manner. First, the teacher instructs students in a concept or skill. Next, the teacher solves example problems with the class, and finally, the students practice on their own. (U.S. Department of Education, 1996). Very rarely are students taught Algebra II through a kinesthetic approach. Nevertheless, the National Research Council (1989) stated that "most students cannot learn mathematics effectively by only listening and imitating; yet most teachers teach mathematics just that way. Most teachers teach as they were taught…" (Midkiff, 1993). Overall, these findings suggest that for kinesthetic learners to achieve in Algebra II, new material should be presented in accordance with their strongest perceptual mode. However, few, if any, studies address this dilemma.

Purpose of the study

This research study examined the attitudes and the academic achievement of both kinesthetic learners and non-kinesthetic learners when they were introduced to new Algebra II concepts through activities that were primarily kinesthetic in nature, compared to kinesthetic and non kinesthetic learners in a traditional classroom.

Definition of Terms

The following definitions are provided for terms having special application in this study.

Learning Styles - The set of behaviors, attitudes and other factors that a learner uses when he/she concentrates on, processes and retains new and difficult information (DeBello, 1989; Dunn and Dunn, 1993).

Perceptual Preferences (Strengths) or Learning Modalities - The senses through which people best take in and process knowledge (Reiff, 1992).

Kinesthetic Learner - A learner that needs to involve large muscle groups, participate in "real-life" activities or involve movement in his/her learning process. This learner has a kinesthetic perceptual preference (Dunn and Dunn, 1993).

Non-kinesthetic Learner - A learner whose perceptual preferences do not include the kinesthetic modality.

Kinesthetic Activities - Activities that involve the use of large muscle groups or body movement.

Traditional Learning Methods - Activities usually used in a typical Algebra II classroom, lecture, drill and practice.

Achievement - Knowledge as measured by difference between pre and post matrix

algebra test developed for this study.

Significance of the Study

Although perceptual preference is only one of the factors involved in an individual's learning style, research studies have suggested it to be an important one (Caine & Caine, 1990, Orsak, 1990). When students are introduced to new material through their perceptual preference, they retain more knowledge than if they are introduced through their least preferred modality (Dunn and Dunn, 1993). In the typical high school mathematics classroom, lecture is the method used to introduce most new material. Examples are often shown to the students by means of a blackboard or overhead projector screen. These methods would satisfy the needs of students with visual or auditory preferences, but do nothing for those needing tactile or kinesthetic activities to learn most effectively. If tactile learners take notes over the material being presented, then their perceptual need is being addressed, but kinesthetic learners do not benefit much through any of these normal classroom procedures. This study will allow Algebra II mathematics teachers to see the results of introducing matrix algebra concepts through kinesthetic activities.

Research Questions

From the literature review the following research questions were made:

Question 1 : In what ways are students with kinesthetic preferences impacted when Algebra II concepts are introduced through kinesthetic lesson?

Question 2: In what ways are students with non kinesthetic preferences impacted when Algebra II concepts are introduced through kinesthetic lessons?

Assumptions and Limitations

This study assumed that none of the students in the traditionally taught classrooms would use kinesthetic methods of learning to reinforce the lessons presented in the classroom. While introducing new material though a student's primary perceptual strength is most beneficial, reinforcement through that perceptual strength would also benefit a student that was introduced in another modality.

It was also assumed that the differences in pre and post test scores were due to the effects of the treatment and not due to other variables not studied here.

There are several limitations inherent in this study. This study was limited to the kinesthetic learners and non-kinesthetic learners in five Algebra II classes taught by two different teachers in the same high school. One of the teachers was the principal researcher. The data collected covered one unit of study in matrix algebra and was collected over a period of two weeks. Anyone attempting to generalize the results of this study should keep these limitations in mind.

Organization of the Study

This section of the research plan provided an introduction to the study, the study's purpose, and its significance. Chapter II will include a review of the literature concerning learning styles. The third chapter will discuss the methodology used in the study. The data collected from the study and its analysis will be in Chapter IV. Chapter V will include a discussion of the findings and recommendations.

CHAPTER II

REVIEW OF LITERATURE

Introduction

Teachers have long recognized diversity among students. Gender, ethnicity, and cultural differences are often more easily recognized than are the differences in the way students receive and process information. Gregoric says, "people through their characteristic sets of behavior tell us how their minds relate to the world and, therefore, how they learn" (Gregoric, 1979, p. 19). Studies over the past three decades have looked at precisely these behaviors that are called a person's learning style. The purpose of this study is to look at the attitudes and achievement of students who have a kinesthetic preference in their learning style. This chapter will include a review of the literature that has been written about learning styles, first by looking at some of the different research that has been done and then by looking at how achievement has been found to be affected by learning style.

Learning Styles Research

"Teachers intuitively know that students learn in different ways" (American Association of School Administrators, 1991, p. 6) and yet most classrooms provide standardization when it comes to instruction. As early as 1892, some components of learning style theory appeared in research literature (Keefe, 1979), but it was not until the 1950's that the term "learning style" first appeared. Many early learning theories were rooted in behaviorism. (American Association of School Administrators, 1991; Raviotta, 1988) with researchers such as Carl Jung (1921) focusing on the ways that people "take-in" information. Jung described four types of learners; feelers, thinkers, sensors and intuitors.

Anthony Gregorc (1979) later combined two types of perceiving with two types of ordering, thus identifying four learning styles: concrete sequential (prefers structured, hands-on, predictable presentations); abstract sequential (prefers logical, often visual or auditory presentations); abstract random (prefers to receive information in unstructured, multi-sensory, imaginative presentations); and concrete random (prefers intuitive, investigative learning) (Gregorc, 1979).

David Kolb (1976) described two kinds of perception, either through concrete experience or through abstract conceptualization. He also theorized that people process either through active experimentation or reflective observation. (Hall, 1993) thus leading him to describe a four quadrant model of learning styles. Bernice McCarthy (1980), an experienced teacher, expounded upon Kolb's and others' work, and created a model She called the 4MAT Model. This model was set up to help with classroom curriculum design.

Walter Barbe and Raymond Swassing (1979) focused their research on modality differences in learners. The sensory channels that we use to receive and retain new information had also been part of the very early learning research but had been limited to just visual and auditory channels (Keene, 1979) where as Barbe and Swassing looked also at the kinesthetic/tactile modality.

In 1967 Professor Rita Dunn of St. John's University, began scrutinizing the research that had been accumulated over the previous eighty years on how people learn. She and Dr. Ken Dunn found repeated information that verified the concept that students exhibit very distinct differences in style when they begin to process and retain new information. They initially found twelve variables that were significantly different among learners, but through later revisions have identified twenty-one elements that make up a person's learning style. These elements were then classified into one of five stimuli groups, environmental, emotional, sociological, physical, or psychological. Environmental elements include noise level, light temperature and design. Emotional elements include motivation, responsibility and structure. Sociological elements take into account whether a learner works better alone, with a peer or as a team member. Physical stimuli include perceptual preferences (or learning modalities), intake, time of day and mobility. Psychological elements look at global versus analytic processing, hemisphericity and impulsive versus reflective thinking (Dunn and Dunn, 1993). In 1991 the American Association of School Administrators reported that the Dunn and Dunn Model of learning styles was the approach used most often in the classroom. The Dunn's identification instrument, The Learning Styles Inventory (Dunn, Dunn, and Price, 1989), is the most widely used assessment in elementary and secondary schools (Raviotta, 1988). Rita Dunn describes learning style as "a biological and developmental set of personal characteristics that make the identical instruction effective for some students and ineffective for others (1993, p. 5).). Use of the Dunn and Dunn inventory allows teachers to match instruction to individual differences (Guild, 1990).

The National Association of Secondary School Principals (NASSP) has researched for more than a decade in the learning styles field. Initially research was conducted to determine the importance of this field and then an instrument was developed to identify student's styles. NASSP divides style preference into four general categories; cognitive styles, perceptual responses, student preferences and instructional preferences. Information from the NASSP offers recommendations on personalized instruction tailored to a student's learning style.

Learning Styles and Achievement

Over the past decade, research on learning styles has been conducted at more than 60 universities, much of it concerning achievement and learning styles (Beaudry, Dunn and Klavas, 1989). There does not appear to be much controversy as to whether or not learning styles play a part in how students learn, but there is some conflict as to how to best use knowledge of learning styles to benefit learners. Most of the conflict found in the research was debate centering around which part of a learner's style needs to be addressed for significant achievement gains.

Keefe believes that educators have usually viewed "instruction and learning as direct correlates" (1989, p. 1). In other words, if instruction is present then learning should follow. Therefore, students should learn if the teacher is working hard. Earlier trends were inclined to blame the student if this learning did not take place. A more recent trend has been to hold the teacher accountable, not the student (Keefe, 1989). The reality that is being found through learning style research is that environment and student learning style (coupled with teaching style) both play an important part in learning.

Correlational studies based on the Dunn and Dunn model have looked at the relationships between learning style and a number of variables including birth order, cognitive development, maturation, hemisphericity, field dependence/independence, global/analytic processing, and self concept (Beaudry, Dunn, and Klavas,1989). Cody's study (as cited in Beaudry, Dunn and Klavas, 1989) found that left-hemisphere youngsters preferred conventional, formal classroom design, more structure, less intake and more visual than tactile or kinesthetic activities than right-hemisphere youngsters. The same study found that gifted students were more often right processors. Right processors in grades five through twelve disliked structure and were strongly peer motivated, but not adult motivated.

Correlational studies also explored the similarities and differences between and among diverse groups. Rita Dunn (1993) reported "there appear to be more differences between how boys and girls learn than between cultural groups"(p.28). Females are more persistent and more willing to conform than males, while males need more intake and mobility. Also many males more often prefer sound in their learning environment while girls often require quiet (Dunn, 1993).

These correlational studies then led to experimental research to determine the effects that learning style has on achievement, attitudes, and/or behavior. Researchers such as DeGregoris (1986), DellaValle (1984), Murrain (1983) and Shea (1985) have used experimental designs to look at different elements involved in learning styles and recorded significant changes when students' learning needs were met (Beaudry, et all, 1989). While many studies done in this field have determined positive results when a student's learning style is met in the classroom, Kenneth Kavale of University of Iowa and Steven Forness of UCLA criticized some studies that concluded that modality teaching will result in improved achievement (American Association of School Administrators).

A significant relationship has been found to exist between the ability to use all learning modalities and achievement (Reiff, 1992). Basically, the research shows that individuals who have the ability to process new information through many perceptual modes have an easier time learning because they can use two or three modalities with equal efficiency. Research on learning styles has indicated that the way teachers present information does have an effect on whether learning happens (American Association of School Administrators, 1991; Caine and Caine, 1990, Reef, 1992).

Pilot studies such as the one reported by Lana Orsak have shown significant gains in academic high school mathematics classrooms when traditional methods of presentation were replaced with presentations adapted to the individual student's perceptual needs (Ors, 1990) . Further investigations about perceptual preferences are needed for understanding what factors will increase achievement. Because kinesthetic lessons are rarely used in secondary math classes (Midkiff, 1993), an important area for investigation should involve the use of kinesthetic activities. This study attempted to fill a gap in the literature that shows the effects of kinesthetic activities in these classrooms.

A study completed with Special Education Learning Disabled and Emotionally Handicapped students found that not only was mathematics achievement increased when the students were taught through their perceptual strength, but the students' attitudes significantly improved (Bauer, et al, 1994). Since this study was limited to a special section of the population, more research is needed to see if adapting the mode of instruction given in a high school mathematics classroom to the needs of the learner will result in a more positive attitude towards mathematics.

CHAPTER III

METHOD

Introduction

This section begins by describing the research approval given and then continues with a description of the subjects that were a part of the study. Information about the instruments that were used follows. The section concludes with a detailed description of the methods and procedures that were implemented in the study.

Research Approval

Federal regulations and Oklahoma State University require an approval of all research studies that involve human subjects. The Oklahoma State University Research Services and the Institutional Review Board use this review to protect the rights of the individuals involved in the research. In compliance with this policy, this research project was approved and assigned the following number: ED 98 - 045. This form is in Appendix C.

Subjects

The population for this study was students enrolled in a public high school in a middle-classed community of approximately 26,000. In the fall of 1997 the enrollment in this high school was about 1200 students. The subjects for the study were selected from five specific sections of college preparatory Algebra II. There was a total enrollment in these five classes of 142 students. Prior to school starting, a computer placed each student in a specific Algebra II class. The five classes in the study were chosen because they were being taught by two teachers familiar with learning styles concepts and both had agreed to use the kinesthetic activities necessary for the study. Both teachers have had approximately the same amount of teaching experience in Algebra II matter. One of the teachers was the principal investigator for the study.

Student participants from these five classes were selected for this study using two criteria. The major criteria was the way the student scored on the Dunn and Dunn Learning Style Inventory (Dunn, Dunn, and Price, 1989). A completed permission form was also necessary. Forty-one students met these criteria and comprised the study sample. Twenty-three students comprised the experimental group while seventeen were part of the control group.

In order to give an accurate description of the subjects in this study, for the purpose of generalizability, gender, age, and ethnicity were asked of each subject. Fifty-four percent of the subjects were female, 46% were male. Eleven percent were sixteen years of age, 16% were 17 and 13% were 18. Caucasians comprised 87.8% of the study, Asian and Native American students were each 2.4% and other ethnicities made up the final 7.4%.

Instruments

The instruments used in this study were the Learning Styles Inventory and a pre/post matrix algebra test designed by the researcher.

The Learning Styles Inventory (LSI) (Dunn, Dunn, and Price, 1989) The LSI is a self-reporting, Likert scale, instrument which consists of 104 questions in 22 areas designed to identify the conditions under which an individual is most likely to learn, remember, and achieve. The instrument was developed through a content and factor analysis with the first edition appearing in 1975 and the most current revision completed in 1989 (Dunn et al, 1989). Students respond on a five point scale ranging from Strongly Disagree (SD) to Strongly Agree (SA). It is a comprehensive look at a student's learning style in relation to five specific areas; environmental, emotional, sociological, physical and psychological. The standard score scale ranges from 0 to 80 with a mean of 50 and a standard deviation of 10. The information from the LSI that was used for this study was the information involving perceptual modalities. These are items twelve through fifteen on the preference summary. These items give scores for auditory, visual, tactile and kinesthetic preferences.

The reliability of the scale was calculated using Hoyt's (1941) formula (Raviotta, 1988). Research in 1988 indicated that 95 percent of the reliabilities of the subscales are equal to or greater than .60 for the Likert scale English translation in grades 5 through 12, with kinesthetic preference having reliability of .74 (Dunn et al, 1989).

Raviotti (1988) reports of two correlational studies done that revealed that the LSI is a measure of learning style. "The extensive use of the LSI in research studies and the related reliability and validity information offer appropriate justification for selection in a study such as this" (Raviotti, 1988, p. 41).

Curry's comparative study (as cited in Dunn, Dunn, and Price, 1989) of nine different learning style instruments, reported the LSI as being the only one that had good or very good reliability and validity. DeBello (1985) also said that the LSI showed predictive validity.

Pre/Post Matrix Algebra II Achievement Test A pretest and equivalent form posttest were developed for this study by using Chapter Five (Matrices and Determinants) equivalent forms tests provided by the publishers of Prentice Hall Algebra 2 with Trigonometry (1990) as a guideline . Each twenty-one question achievement test had items covering addition, subtraction, and multiplication of matrices. Also, determinants, problem solving and applications with matrices were included. Test items related directly to the objectives set by the publisher of the book. A team of two experienced Algebra II teachers, not involved with the study, were given a table specification showing the content areas and levels of difficulty of the items on the test. They were asked to look at the test to check for both types of content validity, item and sampling validity. Both agreed that the test items measured the intended content area and that the questions sampled the total content area.

The two teachers involved with the study wrote a rubric for scoring both the pretest and the posttest. A fifth of the tests were scored together and then each teacher marked half of the remaining tests. After all tests were scored each teacher spot-checked a few of the tests marked by her counterpart to check for interrater reliability.

Research Design and Procedure

This study utilized a pretest/posttest control group experimental design. All students who were enrolled in the five classes were given a pretest prior to the chapter on matrix algebra. Each student was also administered the Learning Style Inventory to evaluate his or her perceptual preference. The teachers received Individual Learning Style Profiles for each student in their Algebra II classes. From the results of these profiles, students were considered to have a kinesthetic preference in one of two ways. Those students with scores of 60 or higher on item "kinesthetic preference" were considered to have a high kinesthetic preference. Also, any student that scored higher on "kinesthetic preference" than on any other perceptual preferences (items labeled "auditory", "visual" or "tactile") became part of the sample group. In the experimental group there were 12 students that were recognized as having high kinesthetic preference. The control group also has 12 students with this preference. Those students with scores 40 or below on item "kinesthetic preference" were considered to have a low kinesthetic preference. Students that had scores of 41 on this item were also included in this group if the kinesthetic modality was their least preferred modality. Eleven students met the necessary criteria to be in the experimental group's non kinesthetic learners, while only six were in the control group data. These cut-off scores were determined by the <u>Learning Style Manual</u> (Dunn, Dunn, and Price, 1989). This differentiation of kinesthetic needs will be one of the independent variables in this study.

The pretest was given a day before the study began and the posttest was administered after the unit had been taught. The pretest and the posttest were alternate forms of the same test to control for internal threats to the validity of the study. The time frame for this study was two weeks. The concept of matrices, addition and subtraction of matrices and scalar multiplication were covered in the first two days. Two days were spent on matrix multiplication. On the fifth day solving equations with matrices was shown. Applications of matrices and the method of finding the determinant of a matrix were the concepts taught in the second week, as well as a short review of what had been previously taught.

Students in two of the classes were taught the unit on matrix algebra using traditional methods of lecture, note taking, drill and practice. These participants were considered to be the control group. Students in the other three classes had the same new concepts introduced through the use of kinesthetic activities. These students were the experimental group. These kinesthetic activities were developed by the two teachers in the study and critiqued by a third "expert" teacher. This expert uses these types of activities regularly in her classroom as well as teaches other educators about learning styles. These activities included, but were not be limited to, using the students as the components of the matrices, having the students actually move through the process of adding the elements of matrix, and using string as a marker to show how to find the determinant of a student formed matrix (see APPENDIX A). Traditional methods of presentation, note taking, drill and practice, followed all kinesthetic presentations to assure that those students with visual, tactile, and auditory preferences were reinforced through their strengths. Experimental and control groups were exposed to the same new material, therefore, the method of instruction was the second independent variable.

All students in the three experimental Algebra II classes participated in the kinesthetic activities even if they were not members of the study. At this time the students had not been informed of their Learning Styles Inventory results, therefore no one knew who was part of the study and who was not.

In the experimental classrooms the meaning of a matrix was introduced by having many students use "sticky notes" on the overhead whiteboards to arrange the constants of three variable systems of equations into the corresponding positions of a matrix. Each student was then given a small white board, marker, and sticky notes to arrange several systems of equations into matrices, thus assuring each student the ability to become actively involved.

To teach addition of matrices, students holding white boards became the elements of matrices. Large matrix brackets were taped off on the classroom floor to represent the matrix notation. A problem was written on the board such as $\begin{bmatrix} 2 & 3 & 4 \\ 1 & -2 & 5 \end{bmatrix} + \begin{bmatrix} 0 & 4 & 5 \\ 2 & 6 & -8 \end{bmatrix}$ and students were designated as specific elements in each matrix. These students wrote the numeral given to them on their white boards and then moved into the floor brackets into the correct position for their element. The two matrices were then added and the corresponding student "elements" moved together into a third bracket, adding their numerals together and showing the sum on one white board per element. Thus the students became components of the answer matrix. This process was repeated numerous times with matrices of differing dimensions. The concept that the dimensions of two matrices being added together had to be the same, became apparent to the students very quickly.

Scalar multiplication was demonstrated by having one student become the constant that a student matrix was to multiplied by. As the "multiplier student" moved next to each element in the matrix, the elements multiplied his/her value by the constant and the subsequent elements of the new matrix were shown on the white boards. This concept of scalar multiplication was then used to introduce an additive identity for a matrix. From this, subtraction of matrices was shown, again using the students as the components of the matrices.

Matrix multiplication was introduced in similar fashion. Two matrices were formed with students holding white boards. A row of elements in the first matrix moved to the corresponding column of the second matrix and the student pairs multiplied their elements together. These products were then added to find the element of the answer matrix which was then written on a board by a student standing in the correct position in the answer matrix. The original row and column moved back into position to continue the multiplication process as the next column was multiplied by the first row. This process was continued until the problem was completed. Several other problems were solved by using different student matrices.

To learn how to find the determinant of a matrix, students were standing in the floor brackets as elements of a 2 x 2 matrix. A string was looped around the first and fourth elements to show that these two elements were to be multiplied. Another string was looped around the second and third elements and their elements multiplied. A fifth student then stood between the products with a large subtraction sign and the difference was found. This was repeated several times with different student matrices while students worked the same problems at their desks with their own white boards.

Similar procedures involving students as elements were used to explain how to solve equations involving matrices. No kinesthetic activities were used to show applications of matrices nor were any used in the review of the unit.

CHAPTER IV

RESULTS

Introduction

This chapter will present the quantitative data that was collected from the study. It will also explain the type of statistical analysis that was used to interpret the results.

Data Analysis

A pretest and equivalent form posttest on matrix algebra was developed specifically for this study. Students' scores for both of these as well as their scores for some individual test question items were recorded. These specific questions had been selected previously as more difficult questions by the panel of Algebra II teachers that checked the validity of the test questions. A difference between each participant's pretest and posttest was found (referred to as pre/post difference). A mean was calculated for each participant's two previous Algebra II tests taken over material covered before the study was conducted. This mean is the data referred to as "average". A difference was then found between that statistic and the corresponding posttest score (referred to as average difference).

A Pearson r was calculated to determine if there was a significant relationship between the pretest scores and posttest scores of each group. When it was found that such a relationship did not exist, a t-test for independent samples was used to look at the pretest/posttest difference and at the average difference of the experimental group and the control group.

Appendix E contains the descriptive statistics that were calculated for each group that was part of the study. The range, mean, variance and standard deviation for the pretest, posttest, difference, average, post/average difference as well as for individual test items can be found there.

Examination of these results indicated essentially no significant difference between the experimental group and the control group both with the kinesthetic learners and in the non-kinesthetic learners (see Table 1 and Table 2). The only statistically significant data found was that of point differences on two specific test items, items 18 and 21. Item 18 asked students to find the determinant of a matrix while item 21 expected them to know that squaring a matrix would find the number of ways an application matrix would allow a certain type of communication. Upon further analysis, it was found that the significance appeared in both the kinesthetic and non kinesthetic classrooms among the kinesthetic learners. The kinesthetic students of one teacher (the principal researcher) scored significantly higher than the kinesthetic students of the other teacher on items 18 and 21 and on the pre/post difference (see Table 3).

Table 1

Mean, Standard Deviation and t-Tests of Kinesthetic Learners in the Experimental and Control Groups

	Experimental		Control Group			
	Mean	SD	Mean	SD	t value	2-tail signif
Pre/post Diff	80.92	13.75	80.00	12.23	.17	.865
Average	73.42	16.27	79.25	8.95	-1.09	.292
Average Diff	15.50	17.80	7.17	12.78	1.32	.203

Table 2

Means, Standard Deviations and t-Tests of Non-Kinesthetic Learners in the Experimental and Control Groups

	Experimental		Control Group			
	Mean	SD	Mean	SD	t value	2-tail signif
Pre/Post Diff	79.36	13.74	83.50	8.14	-.78	.448
Average	78.91	13.60	88.67	4.59	-2.16	.049
Average Diff	10.64	15.98	10.17	4.07	.09	.928

Table 3

Individual Test Items of Kinesthetic Learner
Mean, Standard Deviation and t-tests according to Instructor

	Instructor 1		Instructor 2			
	Mean	SD	Mean	SD	t value	2-tail signif
Item 12	4.64	.63	4.60	.97	.12	.904
Item 13	4.21	1.63	4.70	.95	-.92	.368
Item 15	3.43	2.31	3.30	1.83	.15	.881
Item 16	3.29	2.27	4.20	1.75	-1.11	.881
Item 18	3.14	2.32	5.00	.00	-3.00	.010 *
Item 20	4.86	.54	5.00	.00	-1.00	.336
Item 21	2.93	2.20	5.00	.00	-3.52	.004 *
Pre/Post diff	75.93	12.90	86.8	7.66	-2.45	.023 *

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Introduction

In this chapter some conclusions which can be drawn from the results will be discussed. Recommendations for further research using kinesthetic activities to teach Algebra II students will be given.

Conclusions

The purpose of this study was to see in what ways Algebra II students were impacted when matrix algebra concepts were taught using kinesthetic lessons. The first research question inquired about the effects that these lessons would have on students with kinesthetic preferences. While none of the study's results showed significant statistical differences when using kinesthetic activities rather than traditional activities to teach kinesthetic Algebra II students, there was a large numerical difference in one of the study's findings. Kinesthetic students taught with kinesthetic activities had a mean average from their previous tests that was 5.83 points lower than the mean average of the kinesthetic students taught in the traditional method. The difference between each student's posttest score and previous average was taken and the mean of the students that had kinesthetic activities was 8.33 points higher than that of the students that had been taught in the traditional method. While not statistically significant, this large numerical difference in the opposite direction is worth noting. The small sample size that limited the study and the wide dispersion of previous means may have contributed to statistical significance not appearing from the data. The pilot study reported by Lana Orsak reported significant gains in academic high school mathemetics classrooms when students' individual learning styles were met (Orsak, 1990).

There were statistically significant differences on two of the more difficult questions on the test when the results were sorted according to instructor. The principal investigator's kinesthetic students scored higher than the other instructor's students scored. Both instructors were very familiar with learning style theory, and neither had previously used the specific activities done in the study. However, the investigator has had extensive training in learning style activities, while the other teacher has not. The investigator also used a tactile activity in both the kinesthetic and non kinesthetic classrooms that has always been a part of her traditional method. The other teacher did not use that activity. Either of these discrepancies could have contributed to the differences in the students' scores on these two items.

After the formal study ended, the investigator monitored attitudes and test scores of several of the kinesthetic learners in both the experimental and control groups. Several of the students in the experimental group have maintained test averages that were higher than before the experiment. At least three of the kinesthetic learners who had received kinesthetic lessons disclosed to the investigator that they had truly enjoyed the kinesthetic activities and wanted to know if more of these same type of activities would be used to teach subsequent chapters. Two of these kinesthetic learners said that the algebra had made sense for the first time. One of these students, who had a very low previous average, continued to come in before and after school to use kinesthetic activities since none were being provided in the classroom. This student has continued to improve on subsequent tests and her attitude has changed dramatically. She now believes that she can learn math; she just needs to learn differently. She is also using some of the same kinesthetic techniques to study for other classes.

The study reported by Bauer and others (1994) also found that mathematics achievement as well as attitudes improved when students were taught through their perceptual strengths. Even though the group studied was not similar to the sample used in this study, the results were similar.

In the control group at least two kinesthetic students have continued to show improvement on their tests scores since the experiment, but no attitude change has been noted. One of the students in the control group, who had a very low previous average, has continued to have her test scores decline. She was shown some of the kinesthetic activities available before and after school but has decided not to come in for extra help.

The second research question inquired about the effect that using kinesthetic activities would have on students with non kinesthetic preferences. The study found little difference in the data for non kinesthetic learners in the control group and in the experimental group. Since the experimental group received the same traditional explanation after the initial kinesthetic activities, the learners' needs may have been equally met in both groups. With the students in this study, kinesthetic activities seem to have little effect on non kinesthetic learners if their learning styles are met in other parts of the classroom presentation.

Recommendations

This study was limited by the number of students in the Algebra II classrooms who were chosen to participate. Further limitations reduced the sample to only 41 students, with only 24 of them being kinesthetic learners. These reductions were necessary to ensure that only students with kinesthetic strengths, according to the Dunn and Dunn Learning Style Inventory (1989), were recognized as such . Because a pre-post test design was used, only half of the sample then became the experimental group. It is recommended that further research be done using kinesthetic activities in the high school classroom, but with much larger populations. Because the nature of the students who are being studied limits the sample, it is also recommended that a repeated measures design be used to allow more students to be part of the experimental sample. A repeated measures design would also allow an investigator to view the effect that different levels of teacher training might have on students' learning. Another limitation of his study was that it covered only one two week unit of an Algebra II course. A repeated design study would allow for a more lengthy investigation.

Further investigation is recommended into what types of activities, kinesthetic in nature, have the most effect on kinesthetic learners. This study used activities that had movement within the mathematical process, not just movement for movement's sake. Secondary mathematics teachers could benefit from knowing if movement of any type has a direct impact on the achievement of kinesthetic learners.

Because students' attitudes about their own abilities can have an impact on their learning, it is also recommended that further studies include investigating the attitudes of kinesthetic learners before and after receiving kinesthetic lessons.

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APPENDIXES

APPENDIX A

LEARNING STYLES INVENTORY

INDIVIDUAL PROFILE EXAMPLE

- LEARNING STYLE INVENTORY -

DATE: INDIVIDUAL PROFILE GROUP NO.:

NAME: SEX: GRADE: BIRTHDATE:

GROUP IDENTIFICATION: PONCA CITY OK SPECIAL CODE: YR MO ID. NO.:

SCALES

SCORE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
RAW	6	11	18	8	30	18	13	20	22	15	14	19	5	23	34	19	17	13	20	18	18	23
STD.	31	46	52	44	49	54	51	73	49	58	51	69	34	64	72	53	53	56	62	60	54	62

PREFERENCE SUMMARY

	20 — 30 — 40	40 — 50 — 60	60 — 70 — 80	
1	Prefers Quiet	Noise Level	Prefers Sound	1
2	Prefers Dim	-*-Light	Prefers Bright	2
3	Prefers Cool	Temperature	Prefers Warm	3
4	Prefers Informal	-*- Design	Prefers Formal	4
5	Low	Motivation	High	5
6	Low	Persistent	High	6
7	Low	Responsible (Conforming)	High	7
8	Does not Like	Structure	Wants-	8
9	Prefers Alone	Alone/Peers	Prefers with Peers	9
10	Does not want Present	Authority Figures*-	Wants Present	10
11	Does not Learn in	Several-Ways	Prefers Variety	11
12	Does not prefer	Auditory	Prefers	12
13	Does not prefer	Visual	Prefers	13
14	Does not prefer	Tactile	-*- Prefers	14
15	Does not prefer	Kinesthetic	Prefers	15
16	Does not prefer	Intake-	Prefers	16
17	Prefers Evening	Time of Day	Prefers Morning	17
18	Does not prefer	Late Morning*-	Prefers	18
19	Does not prefer	Afternoon	-*- Prefers	19
20	Does not prefer	Mobility -	- Prefers	20
21	Low	Parent Motivated	High	21
22	Low	Teacher Motivated	-*- High	22

CONSISTENCY: 100 PROFILE NO.: 13

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APPENDIX B

MATRIX PRE TEST AND POST TEST

ALGEBRA II
CHAPTER 5
PRE TEST

NAME ____________________
Hour __________

Use the following matrices to answer questions 1- 14

$A = \begin{bmatrix} 3 & 7 & -9 \\ 1 & 4 & -8 \\ 2 & 5 & -3 \end{bmatrix}$ $B = \begin{bmatrix} 4 & 1 & 7 \\ 1 & -9 & 6 \\ 6 & -6 & 5 \end{bmatrix}$ $C = \begin{bmatrix} 2 & 4 & -3 \\ -3 & 2 & 1 \end{bmatrix}$

$D = \begin{bmatrix} -1 & 4 & -5 \\ 2 & -1 & 3 \end{bmatrix}$ $E = \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix}$ $F = \begin{bmatrix} -1 & 2 \\ 3 & 1 \\ 0 & 4 \end{bmatrix}$

$G = \begin{bmatrix} 6 & -4 & 2 \end{bmatrix}$ $H = \begin{bmatrix} 6 \\ 4 \\ -2 \end{bmatrix}$

____________________ 1. What are the dimensions of matrix F

____________________ 2. Give the element of matrix B that is in the 2nd row, 1st column

____________________ 3. Give the additive inverse of matrix D

____________________ 4. Find ½ of the row matrix

____________________ 5. Find the scalar product of 4 and matrix E

____________________ 6. Write a square zero matrix

Evaluate each expression for the given matrices. If not possible, write UNDEFINED

____________________ 7. $A + B$

____________________ 8. $D + E$

____________________ 9. $C - D$

____________________ 10. $3\,(A - B)$

____________________ 11. $D \cdot C$

____________________ 12. $D \cdot F$

____________________ 13. $G \cdot H$

____________________ 14. $E \cdot F$

Solve the matrix equation:

_______________ 15. $3x - 2\begin{bmatrix} 2 & -1 \\ -3 & -2 \end{bmatrix} = \begin{bmatrix} 8 & -10 \\ 6 & 7 \end{bmatrix}$

Find the values for x and y

_______________ 16. If $7\begin{bmatrix} x & y \end{bmatrix} = \begin{bmatrix} 3x & 9 \end{bmatrix} + \begin{bmatrix} 12 & -2y \end{bmatrix}$

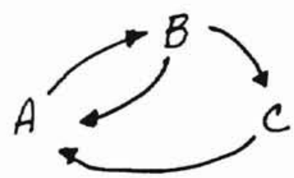
Express this information in matrix form and then solve:

_______________ 17. A travel agent offers three different packages. Package A consists of 3 admission tickets, 8 tickets to rides, and 6 tickets to shows. Package B consists of 2 admission tickets, 6 tickets to rides, and 4 tickets to shows. Package C consists of 4 admission tickets, 10 tickets to rides, and 5 tickets to shows. If the cost of an admission ticket is \$10, the cost of a ride is \$3, and the cost of a show ticket is \$5. Find the total cost of each package

_____________ 18. Find $\begin{vmatrix} 3 & 5 \\ 4 & -1 \end{vmatrix}$

_____________ 19. Find $\begin{vmatrix} -2 & 6 \\ -1 & 3 \end{vmatrix}$

The directed graph below shows the way three people can communicate with each other in one step.



_______________ 20. Write a matrix to show the information in this graph.

_______________ 21. Write a matrix showing the number of ways the three people can communicate with each other in two steps.

ALGEBRA II
CHAPTER 5
Post Test

NAME ____________________
Hour __________

Use the following matrices to answer questions 1- 14

$A = \begin{bmatrix} 3 & 8 & -9 \\ 1 & 5 & -8 \\ 2 & 6 & -3 \end{bmatrix}$ $B = \begin{bmatrix} 3 & 2 & 8 \\ 1 & -9 & 6 \\ 6 & -6 & 5 \end{bmatrix}$ $C = \begin{bmatrix} 2 & 3 & -1 \\ -3 & 2 & 1 \end{bmatrix}$

$D = \begin{bmatrix} -1 & -2 & -3 \\ 2 & -1 & 3 \end{bmatrix}$ $E = \begin{bmatrix} 1 & 5 \\ 3 & 4 \end{bmatrix}$ $F = \begin{bmatrix} -1 & 2 \\ 0 & 4 \\ 3 & 1 \end{bmatrix}$

$G = \begin{bmatrix} 2 & -4 & 6 \end{bmatrix}$ $H = \begin{bmatrix} 4 \\ 6 \\ -2 \end{bmatrix}$

____________________ 1. What are the dimensions of matrix F

____________________ 2. Give the element of matrix B that is in the 2^{nd} row, 1^{st} column

____________________ 3. Give the additive inverse of matrix D

____________________ 4. Find ½ of the row matrix

____________________ 5. Find the scalar product of 4 and matrix E

____________________ 6. Write a square zero matrix

Evaluate each expression for the given matrices. If not possible, write UNDEFINED. ***Show work when possible***.

____________________ 7. A + B

____________________ 8. D + E

____________________ 9. C - D

____________________ 10. 3 (A−B)

____________________ 11. D • C

____________________ 12. D • F

____________________ 13. G • H

____________________ 14. E • F

Solve the matrix equation:

_________________ 15. $3x - 2\begin{bmatrix} 2 & -1 \\ -3 & -2 \end{bmatrix} = \begin{bmatrix} 8 & -10 \\ 6 & 7 \end{bmatrix}$

Find the values for x and y

_________________ 16. If $7\begin{bmatrix} x & y \end{bmatrix} = \begin{bmatrix} 3x & 9 \end{bmatrix} + \begin{bmatrix} 12 & -2y \end{bmatrix}$

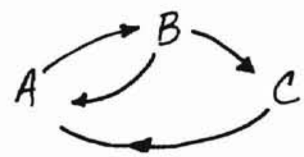
Express this information in matrix form and then solve:

_________________ 17. A travel agent offers three different packages. Package A consists of 3 admission tickets, 8 tickets to rides, and 6 tickets to shows. Package B consists of 2 admission tickets, 6 tickets to rides, and 4 tickets to shows. Package C consists of 4 admission tickets, 10 tickets to rides, and 5 tickets to shows. If the cost of an admission ticket is \$10, the cost of a ride is \$3, and the cost of a show ticket is \$5. Find the total cost of each package

______________ 18. Find $\begin{matrix} 3 & 5 \\ 4 & -1 \end{matrix}$

______________ 19. Find $\begin{matrix} -2 & 6 \\ -1 & 3 \end{matrix}$

The directed graph below shows the way three people can communicate with each other in one step.



_______________ 20. Write a matrix to show the information in this graph.

_______________ 21. Write a matrix showing the number of ways the three

people can communicate with each other in two steps.

APPENDIX C

RESEARCH APPROVAL

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 12-15-97 **IRB #ED-98-045**

Proposal Title: A STUDY OF THE EFFECTS OF KINESTHETIC LESSONS ON THE ACHIEVEMENT OF ALGEBRA II STUDENTS

Principal Investigator(s): Kay Reinke, Paula J. Elmer

Reviewed and Processed as: Expedited with Special Population

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING, AS WELL AS ARE SUBJECT TO MONITORING AT ANY TIME DURING THE APPROVAL PERIOD.
APPROVAL STATUS PERIOD VALID FOR DATA COLLECTION FOR A ONE CALENDAR YEAR PERIOD AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Disapproval are as follows:

Signature: John H. Wheeler

Chair of Institutional Review Board

Date: December 17, 1997

Cc: Paula J. Elmer

APPENDIX D

CONSENT FORM

Dear Student and Parents,

I am a math teacher at Ponca City High School working on an advanced degree at Oklahoma State University. As part of my master's program, I am writing a thesis on the relationship of learning styles to mathematical achievement. As a part of this study, I would like to use information that can be compiled from your test results from some of the chapters that we will be covering in Algebra II. There will be nothing extra that you will be asked to do if you agree to participate in this study. All results will be confidential, and the names of students will not be used in any part of the study.

Students' scores on the Dunn and Dunn Learning Styles Inventory and from specific chapter tests will be accessed and used in the research analysis. If desired, you or your parents may obtain the finished results from this study by contacting our principal, Dr. Sjoberg.

Your participation in this research project is purely voluntary. There will be no penalty if you choose not to participate, and you may withdraw your consent at any time by notifying me at Ponca City High School or by telephone, 767-9555 (voice mail box 1357). If you have any questions you may contact me or Gay Clarkson, IRB Executive Secretary, 305 Whitehurst, Oklahoma State University, Stillwater, OK 74078; telephone number: (405) 744-5700.

Sincerely,

Paula J. Elmer

Please sign the following and return it to your Algebra II teacher.

I have read and fully understand this consent form. I sign it freely and voluntarily.
A copy has been given to me.

____

Name of Student

____

Student Signature

____

Parent Signature

APPENDIX E

DESCRIPTIVE STATISTICS

DESCRIPTIVE STATISTICS FOR KINESTHETIC LEARNERS
TAUGHT WITH KINESTHETIC ACTIVITIES (EXPERIMENTAL CLASSROOM)

	Min	Max	Range	Mean	Varian	Standard Deviation
Pretest	0	26	26	8.00	61.09	7.82
Posttest	65	95	30	88.92	98.45	9.92
Pre/P Diff	44	95	51	80.92	189.17	13.75
Item 12	2	5	3	4.67	.79	.89
Item 13	0	5	5	4.08	2.99	1.73
Item 15	0	5	5	3.42	4.99	2.23
Item 16	0	5	5	3.42	5.54	2.35
Item 18	0	5	5	4.33	2.61	1.61
Item 20	5	5	0	5	0	0
Item 21	0	5	5	4.42	2.27	1.51
Average	37	97	60	73.42	264.81	16.27
Post/Aver Difference	-6	47	53	+15.5	316.82	17.80

DESCRIPTIVE STATISTICS FOR KINESTHETIC LEARNERS TAUGHT WITH TRADITIONAL ACTIVITIES (CONTROL CLASSROOM)

	Min	Max	Range	Mean	Varian	Standard Deviation
Pretest	0	21	21	9.67	51.70	7.19
Posttest	75	100	25	89.58	86.81	9.32
Pre/P Diff	58	100	42	80	149.45	12.23
Item 12	3	5	2	4.58	.45	.67
Item 13	2	5	3	4.75	.75	.87
Item 15	0	5	5	3.33	4.06	2.02
Item 16	0	5	5	3.91	3.36	1.83
Item 18	0	5	5	3.5	5.18	2.28
Item 20	3	5	2	4.83	.33	.58
Item 21	0	5	5	3.17	4.88	2.21
Average	66	90	24	79.25	80.02	8.95
Post/Aver Difference	-15	25	40	+7.17	163.42	12.78

DESCRIPTIVE STATISTICS FOR NON KINESTHETIC LEARNERS
TAUGHT WITH KINESTHETIC ACTIVITIES (EXPERIMENTAL CLASSROOM)

	Min	Max	Range	Mean	Varian	Standard Deviation
Pretest	0	25	25	10.18	60.16	7.76
Posttest	66	100	34	89.55	89.87	9.48
Pre/P Diff	49	97	46	79.36	188.85	13.74
Item 12	5	5	0	5	0	0
Item 13	2	5	3	4.55	1.07	1.04
Item 15	0	5	5	3.55	4.07	2.02
Item 16	0	5	5	3.73	4.02	2.00
Item 18	4	5	1	4.91	.09	.30
Item 20	0	5	5	4.55	2.27	1.51
Item 21	0	5	5	3.09	5.49	2.34
Average	53	96	43	78.91	184.89	13.60
Post/Aver Difference	-10	44	55	10.64	255.25	16.00

DESCRIPTIVE STATISTICS FOR NON KINESTHETIC LEARNERS TAUGHT WITH TRADITIONAL ACTIVITIES (CONTROL CLASSROOM)

	Min	Max	Range	Mean	Varian	Standard Deviation
Pretest	0	20	20	7.5	46.3	6.80
Posttest	76	98	22	91	86.4	9.3
Pre/P Diff	74	92	18	83.5	66.3	8.14
Item 12	4	5	1	4.83	.167	.41
Item 13	5	5	0	5	0	0
Item 15	3	5	2	4.67	.67	.82
Item 16	0	5	5	3.83	4.17	2.04
Item 18	2	5	3	4.5	1.5	1.22
Item 20	0	5	5	3.67	6.87	1.97
Item 21	0	5	5	3.33	6.67	2.58
Average	81	94	13	88.67	21.07	4.59
Post/Aver Difference	6	17	9	10.17	16.57	4.07

2

VITA

Paula Jo Elmer

Candidate for the Degree of

Master of Science

Thesis: A STUDY OF THE EFFECTS OF KINESTHETIC LESSONS ON THE ACHIEVEMENT OF ALGEBRA II STUDENTS

Major Field: Curriculum and Instruction

Biographical:

Personal: Born in Ponca City, Oklahoma on February 19, 1952, the daughter of William D. and Shirley Thomas.

Education: Graduated from Ponca City High School, Ponca City, Oklahoma in May 1970; attended Northern Oklahoma College in Tonkawa, Oklahoma and Oklahoma State University, Stillwater, Oklahoma; received a Bachelor of Science degree from Oklahoma State University in 1974 with a major in Secondary Math Education. Completed the requirements for the Master of Science Degree with a major in Curriculum and Instruction at Oklahoma State University in May 1998.

Experience: Employed as mathematics teacher, Ponca City High School, Ponca City, Oklahoma 1974 to 1980 and 1987 to present.

Professional Organizations: National Council of Teachers of Mathematics, Oklahoma Council of Teachers of Mathematics, Delta Kappa Gamma Kappa Delta Pi.